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Original Article

INFLUENCE OF NUTRIENT MANAGEMENT ON RESIDUAL SOIL FERTILITY AND NUTRIENT BALANCE OF INCEPTISOLS UNDER JAVA CITRONELLA IN VIDARBHA REGION OF MAHARASHTRA

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ABSTRACT

The effect of nutrient amendments on the fertility of residual soil was analyzed by conducting a field study. This study also considered the residual nutrient of the soil post Java citronella harvest. The outcomes suggested that concrete improvement of nitrogen (29.45 kg ha^{-1}) and phosphorus (4.09 kg ha^{-1}) in the soil was detected to the greatest extent on T_{12} treatment (10 t FYM + 140:40:80 kg NPK ha^{-1}) followed by T_{11} treatment (10 t FYM + 100:30:60 kg NPK ha^{-1}). Substantial improvement in soil potassium was noted on T_9 treatment (5 t FYM + 140:40:80 kg NPK ha^{-1}) followed by T_{12} treatment (10 t FYM + 140:40:80 kg NPK ha^{-1}). Therefore, this study helped to establish the fact that the combined application of FYM with chemical fertilizer (10 t FYM + 140:40:80 kg NPK ha^{-1}) improved the nutrients in the soil, thereby facilitating the sustainment of soil fertility and nutrient stability post Java citronella cultivation.

***KEYWORDS:** Residual Soil Fertility, Nutrient Stability, Inceptisols, Java Citronella, Cymbopogon Winterianus & Nutrient Management*

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INTRODUCTION

Java citronella is a tropical plant that originated in Sri Lanka. However, nowadays, it is popularly farmed in Indonesia, China and India, in addition to Sri Lanka. This plant belongs to the Graminae family and is botanically known as Cymbopogon winterianus. In India, it is mainly cultivated in the tea gardens of Assam. The states of Uttar Pradesh., Maharashtra, Karnataka, Gujarat, Manipur, Meghalaya, Tamil Nadu, Nagaland, Uttaranchal, Andhra Pradesh and Tripura also cultivate this plant, but to a lesser expanse. The commercial cultivation of this plant is for its oil, which is obtained by distillation (Shiva et al., 2002).

Java citronella is cultivated in India to a great extent. The area under cultivation is 9000 ha. Annually, 1600 tons of Java citronella is produced in the world. India alone is responsible for the production of 500 tones. India ranks 3rd in the world for the manufacturing of essential oils. Java citronella is one the most important essential oil produced by India. Maharashtra is one of the leading states for Java citronella production. Around 320 ha of agriculture land is employed for this purpose in this state. Annually, Maharashtra produces 25 ton of oil. In Maharashtra, the Vidharbha area alone is responsible for 56.4 ha of cultivation. The foremost districts in Maharashtra where this crop is planted are Nagpur, Yavatmal, Akola, Wardha, Chandrapur and Amravati. Until 2025, the worldwide requirement of this crop is anticipated to be 66000 ha, with India having a market demand up

to 3200 ha. Therefore, this is an advantageous opportunity for farmers to exploit. Maharashtra intends to expand Java citronella cultivation up to 1600 ha, and simultaneously increase its oil production by 480 tons. Currently, the gaining cost of citronella oil and its value-added products is around 325-350 Rupees per kg. Hydroxyl citronellol has a gaining cost of 1150 Rupees per kg. The requirement of Java citronella is projected to be around 120-130 tons per year (Anonymous, 2004), which is a promising hope to the farmers of the crop.

The oil of Java citronella is aromatic and is, therefore, predominantly used by the perfume industry in small quantities. In addition, this oil is used directly as well as indirectly in soaps, soap flakes, cosmetics, detergents, incense sticks, insecticides, *etc*. However, citronellal is mainly employed as a starting raw material to derive other value-added products, such as mosquito repellants. The discarded citronella grass is a suitable raw material for cellulose pulp and paper production with the help of sulphate, sulphite and cold caustic soda.

However, Java citronella cultivation is known to drain the soil of its nutrients. Therefore, appropriate soil management with nutrient amendments is indispensable for maintaining the elevated economic crop yield. These measures also help in retaining soil fertility. The measures employed show that the biomass content of crop and nutrient levels of soil improved significantly after just five months. Furthermore, maximum biomass of crop and maximum nutrient uptake was observed after ten months of crop cultivation (Prakasa Rao and Ganesha Rao, 1986).

Multi-nutrient deficiency and pollution by chemical fertilizers, especially by nitrogen fertilizers, are some the predominant problems in the cultivation of Java citronella. These issues can be resolved by employing integrated nutrient management. Farmers have resorted to increased usage of organic manure with reduced or no fertilizers as a means to overcome the problems related with soil fertility. Increased usage of chemical fertilizers over a long term diminishes soil organic content. The impact is more when organic fertilizers are completely shunned. However, it is challenging to sustain soil fertility and increased productivity with organic fertilizers, as it is neither economical nor suitable for the physiological potential of crop diversity. No field studies have been conducted in the Vidarbha region to explore the nutrient management techniques used for Java citronella cultivation under the prevalent agro-climatic environment. This study purposes to fill in these gaps of information regarding this region's crop cultivation.

MATERIALS AND METHODS

Study Site and Treatment Features

The field study was performed during two *Kharif* seasons in the years 2009-10 and 2010-11. The study was conducted at the Nagarjun Medicinal Plants Garden, Dr. PDKV, Akola. The region lies at 22^0 41' N latitude, 77^0 02' E longitude, and 307.41 meters altitude. The soil in the fields under study was classified as Typic Haplustept, under the soil order Inceptisol. Such soil is medium black in colour, Smectitic type, and having a clay loamy texture. Randomized block design method was used to plan the layout of the study. Totally, the experiment was replicated three times. 13 different treatments as the following were used in the study: control (no fertilizer or manure); 5 t FYM ha^{-1}; 10 t FYM ha^{-1}; 80:20:40 kg NPK ha^{-1}; 100:30:60 kg NPK ha^{-1}; 140:40:80 kg NPK ha^{-1}; 5 t FYM + 80:20:40 kg NPK ha^{-1}; 5 t FYM + 100:30:60 kg NPK ha^{-1}; 5 t FYM + 140:40:80 kg NPK ha^{-1}; 10 t FYM + 80:20:40 kg NPK ha^{-1}; 10 t FYM + 100:30:60 kg NPK ha^{-1}; 10 t FYM + 140:40:80 kg NPK ha^{-1} and 100 kg N by the usage of FYM (after FYM analysis). On the basis of its dry weight, FYM used during the planting season 2009-10 comprised 0.67% N, 0.22% P and 0.49% K. However, on analyzing the nitrogen, phosphorus and potassium content of soil in April 2010, its composition was observed to be 0.64% N, 0.20% P and 0.51% K. This change was noticed subsequent to the 3rd cutting as per treatments. Nitrogen, Phosphorus and Potassium

were added to the soil in doses that corresponded to the treatments. Nitrogen was not directly used, but instead was used in the form of urea. Urea was added to the soil in three split doses after each cutting according to the treatment protocol. Phosphorus and Potassium doses were added to the soil at the time of planting itself. They were introduced as single super phosphate or muriate of potash, as per the treatment requirement.

Sowing and Harvesting

The study started on 7th July 2009, when Java citronella 'Bio-13' plantlets were planted (rooted slips @ 16666 slips ha^{-1}**).** A spacing of 90 x 60 cm was maintained between each planting. The plantlets were irrigated soon after transplantation and thereafter as and when needed during the experiment. Java citronella was harvested by cutting the leaf blade at its base, i.e., approximately 10-12 cm above the ground. During the two seasons of the study, the crop was harvested 6 times.

Soil Sample Processing and Analysis

The surface soil (0-15 cm) was collected from each study plot by employing soil auger. The soil was studied to analyze the effect of nutrient amendments of the treatments on the soil. The surface soil samples were obtained prior to Java citronella planting and after each study year (2009-10 and 2010-11). The initial soil sample (at the onset of the *Kharif* season in 2009) was moderately alkaline (pH 8.18) in nature, with low EC (0.25 dS m^{-1}). The available Nitrogen was 150.67 kg ha^{-1}, available Phosphorus was 19.56 kg ha^{-1} and available Sulphur was 7.78 ppm; all of these nutrients were in reduced amounts. However, the soil had very high levels of available Potassium (380.80 kg ha^{-1}). The micronutrients (Zn, Fe, Mn, and Cu) in the soil exceeded the critical level. Bouyoucos hydrometer method (Bouyoucos, 1928) was used to study the particle size distribution in the soil. Soil pH and EC were determined by using a 1:2.5 soil: water suspension (Jackson, 1973). Available Nitrogen content was determined by alkaline permanganate method (Subbiah and Asija, 1956), available Phosphorus content by Olsen's method (Watanbe and Olsen, 1965), available potassium content by a flame photometer (Jackson, 1967), **and** available sulphur content by turbidimetric method (Chesnin and Yein,1950). Available micronutrients in the soil, *i.e.* Fe, Zn, Mn and Cu, were analyzed by AAS method using DTPA as extractant (Lindsay and Norvell, 1978).

Plant Sample Processing and Analysis

Plant samples were collected from each study plot by the random method. The samples were obtained by cutting the grass close to the ground, as aforementioned. The harvested plant samples were then crushed and pounded using a stainless steel blade grinder (Willey mill), which was electrically operated. The leaves were ground until they obtained thorough fineness. This fine sample was then used to determine the total nutrients content in the leaves. The uptake of nutrients was calculated by multiplying the respective nutrient concentration in percentage by dry matter at each cutting. The plant sample was digested in a microprocessor-based digestion system, which used a combination of concentrated sulphuric acid and salt (Piper, 1966), followed by distillation using an automatic distillation system, to estimate the total nitrogen. Estimation of total phosphorus, total potassium, total sulphur and total micronutrients was by using a di-acid extract. Total phosphorus estimation was done spectrophotometrically by Vanadomolybdate phosphoric acid yellow color method (Kitson and Mellon, 1944), which used a UV-based double beam spectrophotometer. Total potassium estimation used a flame photometer (Piper, 1966). Total sulphur was calculated spectrophotometrically by the turbidimetric method (Chesnin and Yien, 1950) using a UV-based double beam spectrophotometer. Total micronutrient content

(Fe, Zn, Mn and Cu) was estimated with the help of an atomic absorption spectrophotometer (Issac and Kerber, 1971).

Statistical Analysis

Statistical analysis was conducted according to the method of Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

Residual Soil Fertility and Nutrient Stability

The Java citronella (*Cymbopogon winterianus*) grown successively for two years removed considerable amount of nutrients from the soil. Thus, the information on harvest of nutrients and nutrient stability over a period is useful to understand the status of nutrients. The data regarding the balance of N, P and K at the end of two years crop cycle are presented in table 1, 2 and 3 respectively.

Nitrogen Balance

The applied nitrogen through NPK fertilizer and that released through mineralization of organics (FYM) is subjected to 1) Absorption by the plants 2) Leaching 3) Immobilization and 4) Volatilization. Therefore, the nitrogen balance in the soil after two years of field experimentation is worked out and the data on the nitrogen balance in the soil is presented in table 1.

The data (table 1) indicated that the expected balance of N was markedly highest (336.19 kg ha^{-1}) with the application 10 t FYM + 140:40:80 kg NPK ha^{-1} (T_{12}) followed by the expected balance of 302.89 kg ha^{-1} noticed with the treatment T_9 (i.e. 5 t FYM + 140:40:80 kg NPK ha^{-1}) and 282.26 kg ha^{-1} with T_{11} (i.e. 10 t FYM + 100:30:60 kg NPK ha^{-1}). The data further revealed that the total N uptake in two years was also markedly higher with these treatments. Comparatively more N was added in two years due to application of these treatments (T_{12}, T_9 and T_{11}) which resulted in increase in the N uptake and also recorded the increased expected N balance.

On perusal of the data on actual N status after two years, it is observed that the actual N status was varied from 132.12 -180.12 kg ha^{-1} as against the initial status of 150.67 kg N ha^{-1}. Comparatively higher available N status was observed with the treatment T_{12} (10 t FYM + 140:40:80 kg NPK ha^{-1}) followed by T_{11} (i.e. 10 t FYM + 100:30:60 kg NPK ha^{-1}).

Furthermore, the obtained data indicated the occurrence of a higher expected N balance on nutrition amendment treatments when compared to the actual balance of soil N. However, for the control, the actual N balance was higher than the nutrition amendment treatments. On totaling the total nitrogen involved in a balance sheet, there remained some amount of N that could not be accounted. This observation could be attributed to the fact that the supplementation of the soil with FYM and NPK fertilizers proliferates soil microorganisms, which could convert the organically bound N to inorganic forms (Das *et al*., 2004). In addition, N has high mobility and is rapidly lost by leaching, volatilization and denitrification processes. These events can form unaccountable nitrogen, which is manifested in the balance sheet.

Soil N was noticed to be lost in elevated levels on usage of 10 t FYM + 140:40:80 kg NPK ha^{-1} (T_{12}) supplement. This was followed by the usage of 5 t FYM + 140:40:80 kg NPK ha^{-1} (T_9) and 10 t FYM + 100:30:60 kg NPK ha^{-1} (T_{11}) supplements.

Maximum increase in soil nitrogen levels (29.45 kg ha^{-1}) was on using 10 t FYM + 140:40:80 kg NPK ha^{-1} treatment, whereas maximum decrease in soil nitrogen levels (-18.55 kg ha^{-1}) was in the control. This decrease recorded in

the control could be because of the absence of FYM or NPK supplementation and the presence of nitrogen uptake (41.80 kg ha^{-1}) by the control plant. These results corroborate the findings of Kharkar *et al*. (2000) and Singh *et al*. (2006).

Phosphorus Balance

According to Table 2, after nutrient amendments of soil, the balance of available phosphorus after harvesting of Java citronella was highest (43.23 kg ha^{-1}) by T_{12} treatment (10 t FYM + 140:40:80 kg NPK ha^{-1}) followed by T_9 treatment (5 t FYM + 140:40:80 kg NPK ha^{-1}). The lowest level (5.33 kg ha^{-1}) of available phosphorus was recorded in T_1 treatment (control). The expected balance of P was higher than actual balance in the following treatments: T_6, T_8, T_9, T_{11}, T_{12} and T_{13}, in which either 30-40 kg P ha^{-1} was applied alone or as a mixture with FYM. However, the other treatments recorded a comparatively low expected P balance. The significant accumulation of actual P levels by nutrient amendments could be because of the impact of FYM along with graded doses of NPK. These chemical fertilizers help in improving the labile P levels in soil by means of the complex cationic action of cations such as Ca^{2+} and Mg^{2+} (Bharadwaj and Omanwar, 1994).

The actual P status after two year study was in the range of 18.63-23.65 kg P ha^{-1} as against the initial status 19.56 kg P ha^{-1}.

The data in respect of apparent gain or loss revealed that there was a gain of 23.83 kg ha^{-1} phosphate in T_4 (80:20:40 kg NPK ha^{-1}) while, apparent loss of phosphate was highest (-19.58 kg ha^{-1}) in treatment T_{12} receiving 10 t FYM + 140:40:80 kg NPK ha^{-1} after the harvesting of crop, over initial status of soil. This may be due to addition of P doses in soil with higher uptake of P by the crop. The maximum uptake of P (98.33 kg ha^{-1}) was recorded with treatment of T_{12} where in 10 t FYM along with 140:40:80 kg NPK ha^{-1} was applied.

The actual status of available phosphate in soil was comparatively increased in all the treatments except treatment T_2 (5 t FYM ha^{-1}) clearly indicating the beneficial effect due to application of higher doses of FYM (T_3 and T_{13}) alone, graded doses of NPK alone or in combination with FYM doses @ 5 t and 10 t ha^{-1} (T_7 toT_{12}). While the data in respect of actual gain or loss revealed that there was maximum gain (4.09 kg ha^{-1}) of phosphorus in T_{12} (10 t FYM + 140:40:80 kg NP ha^{-1}) followed by T_{11} (10 t FYM + 100:30:60 kg NPK ha^{-1}). The actual highest loss of phosphorus (-0.93 kg ha^{-1}) was observed in T_1 (control). This might be due to no addition of phosphorus with the continuous uptake of P by the crop. Thus, data indicated that the actual gain of P was increased due to application of FYM along with graded doses of NPK.

Potassium Balance

According to table 3, at the start of the experiment, the level of available potassium in soil was 380.80 kg ha^{-1}. This level was observed to increase gradually during the two years cultivation of Java citronella, and reached a maximum of 392.12 kg ha^{-1} after the harvest of the crop. The maximum uptake (260.61 kg ha^{-1}) of potassium was recorded in T_{12} treatment, which received 10 t FYM + 140:40:80 kg NPK ha^{-1}, whereas the least potassium uptake was recorded in T_1 (control).

Post-harvesting, the expected balance of potassium was highest (418.25 kg ha^{-1}) on T_{13} treatment (100 kg N by the usage of FYM, as detected by FYM analysis). Such an observation could be because of the less uptake of K (115.37 kg ha^{-1}) by the crop. The expected balance of potassium (312.59 kg ha^{-1}) was lowest on T_4 treatment (80:20:40 kg NPK ha^{-1}). However, the K uptake was noticed to be relatively higher than the addition of K (80 kg ha^{-1}), which resulted in the lowest expected K balance in the soil. The actual K balance was relatively higher than the expected K balance. Such an observation was as a result of the various nutrient amendments to Java citronella. The only deviation was seen with the

treatment of 100 kg N ha^{-1} through FYM. The accumulation of K (152.82 kg ha^{-1}) through this treatment was because of relatively lesser uptake of K (115.37 kg ha^{-1}), which resulted in higher expected K balance because of the apparent loss of K, which was a maximum of -32.61 kg ha^{-1}. The apparent gain of K in soil was evidently higher (66.25 kg ha^{-1}) on T_4 treatment (80:20:40 kg NPK ha^{-1}).

Available potassium levels improved gradually in all the treatments except in T_1 (control), T_2 (FYM @ 5 t ha^{-1}) and T_4 (80:20:40 kg NPK ha^{-1}) treatments. In these treatments, the uptake of K was relatively faster than its supply. Such a fast uptake could be the cause of the reduced available K levels. The maximum increase (11.32 kg ha^{-1}) in potassium levels was by T_9 treatment (5 t FYM + 140:40:80 kg NPK ha^{-1}), followed by T_{12} treatment (10 t FYM + 140:40:80 kg NPK ha^{-1}). The maximum decrease (-13.77 kg ha^{-1}) in potassium levels was observed in T_1 (control), followed by T_2 (FYM @ 5 t ha^{-1}).

Accordingly, this study unambiguously reports that the combined supplementation of soil with FYM incorporated with inorganic chemical fertilizer has a positive outcome. This combined supplementation enables to increase the available potash content in the soil to maximum levels. This increase could be as a result of direct accumulation of K by its addition, reduced K fixation and K discharge by the organic matter and clay interface (Bharadwaj and Omanwar, 1994).

CONCLUSIONS

This study helped to establish the fact that the combined application of FYM with chemical fertilizer (10 t FYM + 140:40:80 kg NPK ha^{-1}) improved the nutrients in the soil, thereby facilitating the sustainment of soil fertility and nutrient stability post Java citronella cultivation.

Table 1: Balance of Available Nitrogen in Soil after Two Years of Crop Cycle (2009-2011) as Influenced by Different Treatments of Nutrient Management

Treatments	Initial N Status (kg ha^{-1})	Total N Added in Two Years (kg ha^{-1})	N Uptake in Two Years (kg ha^{-1})	Expected N Balance (kg ha^{-1})	Actual N Status After Two Years (kg ha^{-1})	Apparent Gain/Loss (kg ha^{-1})	Actual N Gain/Loss (kg ha^{-1})
	A	B	C	D=(A+B)-C	E	F=(E-D)	G=(E-A)
T_1 - Control	150.67	0.00	41.80	108.87	132.12	23.25	-18.55
T_2 - 5 t FYM ha^{-1}	150.67	65.50	83.32	132.85	144.22	11.37	-6.45
T_3 - 10 t FYM ha^{-1}	150.67	131.00	95.94	185.73	163.29	-22.44	12.62
T_4 - 80:20:40 kg NPK ha^{-1}	150.67	160.00	141.79	168.88	159.80	-9.08	9.13
T_5 - 100:30:60 kg NPK ha^{-1}	150.67	200.00	152.51	198.16	168.31	-29.85	17.64
T_6 - 140:40:80 kg NPK ha^{-1}	150.67	280.00	168.89	261.78	173.25	-88.53	22.58
T_7 - 5 t FYM + 80:20:40 kg NPK ha^{-1}	150.67	225.50	165.18	210.99	167.75	-43.24	17.08
T_8 - 5 t FYM + 100:30:60 kg NPK ha^{-1}	150.67	265.50	177.24	238.93	170.84	-68.09	20.17
T_9 - 5 t FYM + 140:40:80 kg NPK ha^{-1}	150.67	345.50	193.28	302.89	175.83	-127.06	25.16
T_{10} -10 t FYM + 80:20:40 kg NPK ha^{-1}	150.67	291.00	190.47	251.20	175.27	-75.93	24.60
T_{11} -10 t FYM + 100:30:60 kg NPK ha^{-1}	150.67	331.00	199.41	282.26	177.54	-104.72	26.87
T_{12} -10 t FYM + 140:40:80 kg NPK ha^{-1}	150.67	411.00	225.48	336.19	180.12	-156.07	29.45
T_{13} -100 kg N through FYM (based on FYM analysis)	150.67	200.00	107.59	243.08	165.71	-77.37	15.04

Table 2: Balance of Available Phosphorus in Soil after Two Years of Crop Cycle (2009-2011) as Influenced by Different Treatments of Nutrient Management

Treatments	Initial P Status (kg ha^{-1})	Total P Added in Two Years (kg ha^{-1})	P Uptake in Two Years (kg ha^{-1})	Expected P Balance (kg ha^{-1})	Actual P Status After Two Years (kg ha^{-1})	Apparent Gain/Loss (kg ha^{-1})	Actual P Gain/Loss (kg ha^{-1})
	A	B	C	D=(A+B)-C	E	F=(E-D)	G=(E-A)
T_1 - Control	19.56	0.00	14.23	5.33	18.63	13.30	-0.93
T_2 - 5 t FYM ha^{-1}	19.56	21.00	34.76	5.80	19.22	13.42	-0.34
T_3 - 10 t FYM ha^{-1}	19.56	42.00	42.38	19.18	20.74	1.56	1.18
T_4 - 80:20:40 kg NPK ha^{-1}	19.56	40.00	62.55	-2.99	20.84	23.83	1.28
T_5 - 100:30:60 kg NPK ha^{-1}	19.56	60.00	67.46	12.10	21.17	9.07	1.61
T_6 - 140:40:80 kg NPK ha^{-1}	19.56	80.00	73.92	25.64	22.34	-3.30	2.78
T_7 - 5 t FYM + 80:20:40 kg NPK ha^{-1}	19.56	61.00	72.96	7.60	21.65	14.05	2.09
T_8 - 5 t FYM + 100:30:60 kg NPK ha^{-1}	19.56	81.00	77.89	22.67	21.89	-0.78	2.33
T_9 - 5 t FYM + 140:40:80 kg NPK ha^{-1}	19.56	101.00	84.78	35.78	23.17	-12.61	3.61
T_{10} -10 t FYM + 80:20:40 kg NPK ha^{-1}	19.56	82.00	82.73	18.83	22.97	4.14	3.41
T_{11} -10 t FYM + 100:30:60 kg NPK ha^{-1}	19.56	102.00	86.84	34.72	23.34	-11.38	3.78
T_{12} -10 t FYM + 140:40:80 kg NPK ha^{-1}	19.56	122.00	98.33	43.23	23.65	-19.58	4.09
T_{13} -100 kg N through FYM (based on FYM analysis)	19.56	64.09	49.31	34.34	21.14	-13.20	1.58

Table 3: Balance of Available Potassium in Soil after Two Years of Crop Cycle (2009-2011) as Influenced by Different Treatments of Nutrient Management

Treatments	Initial K Status (kg ha^{-1})	Total K Added in Two Years (kg ha^{-1})	K Uptake in Two Years (kg ha^{-1})	Expected K Balance (kg ha^{-1})	Actual K Status After Two Years (kg ha^{-1})	Apparent Gain/Loss (kg ha^{-1})	Actual K Gain/Loss (kg ha^{-1})
	A	B	C	D=(A+B)-C	E	F=(E-D)	G=(E-A)
T_1 - Control	380.80	0.00	39.38	341.42	367.03	25.61	-13.77
T_2 - 5 t FYM ha^{-1}	380.80	50.00	84.44	346.36	370.04	23.68	-10.76
T_3 - 10 t FYM ha^{-1}	380.80	100.00	99.43	381.37	383.87	2.50	3.07
T_4 - 80:20:40 kg NPK ha^{-1}	380.80	80.00	148.21	312.59	378.84	66.25	-1.96
T_5 - 100:30:60 kg NPK ha^{-1}	380.80	120.00	162.07	338.73	381.54	42.81	0.74
T_6 - 140:40:80 kg NPK ha^{-1}	380.80	160.00	181.78	359.02	385.44	26.42	4.64
T_7 - 5 t FYM + 80:20:40 kg NPK ha^{-1}	380.80	130.00	182.10	328.70	386.04	57.34	5.24
T_8 - 5 t FYM + 100:30:60 kg NPK ha^{-1}	380.80	170.00	196.75	354.05	388.17	34.12	7.37
T_9 - 5 t FYM + 140:40:80 kg NPK ha^{-1}	380.80	210.00	217.05	373.75	392.12	18.37	11.32
T_{10} -10 t FYM + 80:20:40 kg NPK ha^{-1}	380.80	180.00	209.85	350.95	387.19	36.24	6.39
T_{11} -10 t FYM + 100:30:60 kg NPK ha^{-1}	380.80	220.00	221.61	379.19	389.17	9.98	8.37
T_{12} -10 t FYM + 140:40:80 kg NPK ha^{-1}	380.80	260.00	260.61	380.19	391.65	11.46	10.85
T_{13} -100 kg N through FYM (based on FYM analysis)	380.80	152.82	115.37	418.25	385.64	-32.61	4.84

REFERENCES

1. *Anonymous. (2004). Survey and Study Report of Aromatic Plants Cultivation, Processing, Marketing and Export in Maharashtra State, 2003-04 for Government of Maharashtra, submitted by SBPL, Saraswati Bio-tech Pvt. Ltd., 1 Subibi, opp. IIT maingate, Powai, Mumbai-400076. www.saraswatibiotech. com.*

2. *Bharadwaj, V. and Omanwar, P.K. (1994). Long term effect of continuous rotational cropping and fertilization on crop yields and soil properties. II. Effect on EC, pH, organic matter and available nutrients of soil. Journal of the Indian Society of Soil Science 42, 387-392.*

3. *Bouyoucos, G.G. (1928). The hydrometer method for making a very detailed mechanical analysis of soils. Soil Science 26, 233-238.*

4. *Chesnin, L. and Yien, C.H. (1950). Turbidimetric determination of available sulphur. Soil Science Society America Proceedings 15, 149-151.*

5. *Das, A., Prasad, M. and Gautam, R.C. (2004). Residual effect of organic and inorganic sources of nitrogen applied to Cotton on succeeding Wheat. Indian journal of Agronomy 49, 143-146.*

6. *Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for Agricultural Research, John Wiley & Sons. New York. pp. 241-266.*

7. *Issac, R.A. and Kerber, J.D. (1971). Atomic absorption and flame photometry: Technique and uses in soil, plant and water analysis. pp. 17-37*

8. *Jackson, M.L. (1967). Soil Chemical Analysis. Prentice Hall India Pvt. Ltd., New Delhi.*

9. *Jackson, M.L. (1973). Soil Chemical Analysis (Edn. 2) Prentice Hall of India Pvt. Ltd., New Delhi. pp. 69-182.*

10. *Kharkar, P.T., Thosar, V.R. and Kolhe, R.K. (2000). Balance sheet of soil nitrogen and phosphorus of legumes, oilseeds inclusive crop sequence in Vertic Ustochrepts. PKV Research Journal 24 (2), 108-111.*

11. *Kitson, R.E. and Mellon, M.G. (1944). Colorimetric determination of phosphorus as molybdivandophosphoric acid. Ind. Eng. Chem. Anal. Ed. 16:379-383.*

12. *Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Science Society America Journal 42, 421-428.*

13. *Prakasa Rao, E.V.S. and Ganesha Rao, R.S. (1986). Biomass accumulation and nutrient uptake patterns in Java citronella (Cymbopogon winterianus Jowitt.). Indian Perfumer 30 (4), 487-492.*

14. *Piper, C.S. (1966). Soil and Plant Analysis. Hans Publishers, Bombay.*

15. *Shiva, M.P., Lehri, A. and Shiva, A. (2002). Citronella. Aromatic and Medicinal Plants. Published by International Book Distributors, Dehradun (Uttaranchal), pp.110-116.*

16. *Singh, G.K., Singh, J., Singh S. and Walia, S.S. (2006). Role of biofertilizers in enhancing the efficacy of inorganic fertilizers in relation to growth and yield of Wheat. Crop Research 31(1), 17-21.*

17. *Subbiah, B.V. and Asija, G.V. (1956). A rapid procedure for estimation of available nitrogen in soil. Current Science 25(8), 259-260.*

18. *Watanabe, F.S. and Olsen, S.R. (1965). Test of ascorbic acid method for determining phosphorus in water and sodium bicarbonate extracts of soils. Proceedings Soil Science Society America 29, 677-678.*